United States Department of Agriculture.

BUREAU OF SOILS—CIRCULAR NO. 9.

MILTON WHITNEY, *Chief of Bureau.*

SOIL SURVEY AROUND IMPERIAL, CAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., January 10, 1902.

SIR: For some time an active interest has been taken in the development of what is known as the Colorado Desert in San Diego County, the extreme southern portion of California. This area is undoubtedly the site of an old inland sea which has long since dried up, leaving a basin, at the bottom of which is the Salton Sink at a depth of 280 feet below the present sea level, with a surface heavily incrusted with salts which are mined for domestic purposes. The rim of this basin is composed of soils which have been considerably modified by the occasional overflow of the Colorado River, which runs into this area for a short time every few years.

From the climate of this region, and the success that has been attained in the irrigation of a small area south of Yuma, it has been supposed that equal success could be attained here, provided water were available for irrigation. The country has frequently been compared with the Nile Valley, and the Department has looked to this area as a promising field for the introduction of Egyptian cotton, the date palm, and other crops imported from northern Africa.

After considerable agitation by engineers and capitalists a canal has finally been constructed from the Colorado River through about 60 miles of Mexican territory, and the water delivered at a point on the international boundary at Calexico, and sold there to mutual water companies for distribution to the land owners in this country. Although water was not available for irrigation until June, 1901, and then only over a small portion of the area, a great many settlers have gone into the country, towns are springing up, a national bank has been organized, and a railroad is projected.

A number of requests were received by the Bureau of Soils for a soil survey of this area, so that some sure basis might be obtained for the establishment of agricultural industries. Such a survey has now been made of a portion of the area, comprising altogether about 169 square miles in the most important part of the irrigated district, and the condition of the soils, as regards the possibilities of their cultivation, the amount of alkali they contain, and their adaptation to crops, has been found to be much more serious than was anticipated. As the safe development of the country will have to follow certain definite lines, and as the enterprise is just starting, it is considered advisable to issue a preliminary circular, giving the results of the survey as a guide to the safe location of farms and the cultivation and care of the lands.

The soil survey shows that of the 169 square miles surveyed about 51 per cent is either too rough for economical irrigation or contains too high a salt content for any but the most alkali-resistant plants to withstand. The remaining 49 per cent of the area it is believed can be safely cultivated, provided suitable precautions are taken

in the use of a proper amount of irrigation water, in the adoption of careful methods of cultivation, and, where necessary, in the installation of underdrainage to carry off the excess of seepage waters and alkali.

It is to be regretted that the whole area which it is proposed to irrigate could not have been surveyed; but the limited time which could be given to this locality by reason of the lack of sufficient appropriation and the pressure for work elsewhere made it impossible to accomplish more than has been done. The only safe basis upon which lands can be purchased and crops and methods of cultivation selected is a careful and systematic examination and survey of the soils which it is proposed to irrigate. This would require about six months and an expenditure of about $5,000, a sum which is not available in the appropriations for this Bureau. Such a survey would give a detailed map of every section of land, and an alkali map showing the condition of the soil regarding the presence of alkali salts to a depth of 6 feet or more; and would be a safe basis for the purchase of land and the development of the country.

If there is any general desire for the extension of this soil-survey work it would be well either to ask Congress for a special appropriation for this specific work or to arrange for some State or local cooperation which would enable the survey to be made in the near future.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

REPORT BY THOS. H. MEANS AND J. GARNETT HOLMES.

AREA SURVEYED.

The part of the Colorado Desert investigated by this Bureau extends from the international boundary line at the town of Calexico northward 21 miles. The area includes T. 14 S., R. 14 E., T. 15 S., R. 14 E., T. 16 S., R. 14 E., T. 16 S., R. 15 E., T. 17 S., R. 14 E., and T. 17 S., R. 15 E. The area is entirely within San Diego County, Cal., and lies about 115 miles east of the city of that name. Yuma, Ariz., is about 60 miles to the eastward.

Over the area mapped borings were made to a depth of at least 6 feet and were examined by the electrical method to determine the percentage of alkali salts. Note was made of conditions between the points of sampling, and from these data the soil and alkali maps given on pages 7 and 11 were constructed. Borings to a depth of 18 feet were taken at a few places to determine the amount of alkali in the deeper subsoil. In the field about 900 samples were examined. A number of samples were sent to the laboratories for analysis and for the additional information regarding the kind of alkali and for mechanical analyses.

TOPOGRAPHY.

The area mapped is a part of the delta of the Colorado River. The surface in general is apparently level—a smooth, gently sloping plain, admirably adapted for irrigation. The general fall is about 5 feet to the mile. Over the greater part of the area between Salton

and New rivers no leveling whatever is necessary for irrigation, the surface being smooth, level, and practically devoid of vegetation.

Salton River enters the United States in the southeast corner of T. 17 S., R. 15 E., and flows in a general northerly direction to a point north of the area mapped, where it turns northwest and eventually empties into Salton sink. For the first 25 miles of its course in the United States its banks are low; but farther north bluffs 40 to 60 feet high are found on either side. New River crosses the international boundary 7 miles west of the Salton, flows northwest for 7 miles, makes a great bend toward the west, and flows back northeast, cutting the area mapped in the northwest corner of T. 14 S., R. 14 E., making a large area between the two rivers which is considered the best part of the delta in this country. Both the rivers are dry except in time of the highest floods in the Colorado, when water breaks over the divide and runs in them for a short time.

The areas shown on the soil map as sand dunes are covered with dunes and hummocks 3 to 15 feet in height. The leveling of such land will be found expensive, and at the present prices assigned to land will not prove profitable. However, should transportation facilities become better and land under cultivation bring a higher price than is now the case much of this dune land can be leveled and reclaimed. By far the greater part of the dunes are free from harmful quantity of alkali salts, and the porous nature of the material will prevent the rise of the alkali if the level of standing water is kept so low that the upward capillary movement is unable to raise the water from the water table to the surface of the ground.

Around the western, southern, and southeastern sides of Mesquite Lake the lands are in places badly gullied and the amount of good land is small. Other than these few exceptions the land of the desert is beautifully leveled for irrigation and requires but the throwing up of small levees to permit irrigation.

The topography is shown by the contour lines upon the soil map on page 7. These contour lines are made from levels along section lines, and therefore do not show the minor details of topography. We are indebted to the California Development Company for the base and topographic map.

All of this part of the delta is below sea level. The basin extends to Salton Sink, which is about 280 feet below sea level. The basin is surrounded by a well-defined beach line, which is approximately at sea level, showing that there has been very little accumulative elevation or depression since the basin was a part of the ocean. The favored explanation of the formation of the country is that the Colorado River filled in the basin near its mouth, the greater deposition being nearest the river, until this part of the sea was cut off, and became an inland lake, from which the water has evaporated.

The whole delta is deposited in regular strata from 0.01 inch to 2 or 3 inches in thickness, most of the soils presenting the appearance in cross section of a shale or argillaceous sandstone. These strata are for the most part horizontal—good cross sections being exposed in the cuts of New and Salton rivers. Along Superstition Mountain, about 15 miles west of Imperial, the sediments have been uplifted and broken, exposing the deposits to a great depth. An examination of this section shows that the same general character of deposits extends to a depth of 500 feet. Several species of shells are found on the surface of the desert. Mr. Simpson, of the Smithsonian Institution, has identified these shells as fresh or possibly brackish water species which are found living to-day under suitable conditions. These would indicate that the surface of the desert was formed from fresh water or water slightly brackish. The presence of other beach lines below the line of present sea level is supposed to show that there have been periods of partial refilling of the basin from the extreme floods of the Colorado River. Such a refilling on a small scale occurred in 1891, when the bottom of the basin at Salton was flooded. During these times of partial refilling with fresh water these fresh-water shells were either washed in with the sediments or lived along the mud flats covered with shallow water.

DEVELOPMENT OF THE IRRIGATION SYSTEM.

Ever since the Colorado Desert was surveyed in 1854, schemes have been discussed to bring the water of the Colorado River to the land. Actual work on surveys for the canal system began in 1891, when Mr. C. R. Rockwood became identified with a company whose first plans were to take the water out a few miles above Yuma, carry it down, and flume across the river—the water to be used on lands in Mexico. In the financial panic of 1893 this company went to pieces. The difficult engineering features of this project prevented it from again being seriously discussed. With great tenacity of purpose, Mr. Rockwood continued to devote his time and energies to interesting capital in irrigating at least a part of the desert, and the result was the formation in 1900 of the California Development Company. This company is made up of a corporation in both the United States and Mexico, since a part of the company's works and canals are in Mexico.

The California Development Company is a stock company, the shares of which may be disposed of at will by the owners. It is not the policy of the company to actually irrigate lands in the United States, but to sell water to mutual irrigation companies at the border line, these companies having contracts which specify that not more than 50 cents per acre-foot will ever be charged for water and that at least 1 acre-foot of water must be paid for each year on every acre of

land owning water rights. These mutual companies are made up of the owners of the land who have purchased water stocks from the California Development Company, which stocks are made appurtenant to the land. Water stocks began selling at $8 with a $1 bond, acceptable as future payment of stock, issued for each of the $3 of the first payment, making these stocks actually cost but $5.75 per acre. The demand for land and stocks was so great that the company raised the price from time to time until now (January, 1902) stocks are selling for $20 per share, $5 cash, and the balance to be paid in five yearly installments. For the price paid for stocks the California Development Company builds all canals which are to be given to the mutual companies when they assume control in the different districts. An assessment will be made by these mutual companies for running expenses, which must be paid by the farmer in addition to the 50 cents per acre-foot for water.

THE SYSTEM AS PLANNED.

The heading of the canal is 7½ miles below Yuma, on the California side of the river. The water will be carried from this point in a large canal, or several smaller parallel ones, 8 miles to the channel of the Salton River, where the natural channel is used to carry the water about 60 miles westward, running through a tract of 100,000 acres in Mexico, owned by the California Development Company, to the area to be irrigated in the United States. It will be taken out of the Salton a little way below the international boundary line and carried into the United States in a large 60-foot-bottom canal, with a capacity of 25,000 inches, or 5,000 second-feet. This canal is to irrigate that part of the delta included between Salton and New rivers. After entering the United States for a short distance, this large canal is to be changed into two 30-foot canals, side by side; the object being to use one while the other is being cleaned. The other canals are planned to leave the Salton at various points to irrigate lands in Mexico and on the east side of Salton River and west side of New River in the United States.

PRESENT DEVELOPMENT.

Water was first brought to the area in June, 1901, in a small ditch along the route of the proposed larger one. This water is used for domestic purposes—water of stock and irrigating a small amount of land. The greater part of the main canal to the point where the 30-foot canals commence is finished. From this point one of the 30-foot canals is for the most part finished to Imperial, and many of the laterals are constructed. The permanent heading at the Salton River, 7 miles southeast of Calexico, consisting of combined heading and 8-foot drop, has been built, but beyond this there are no gates or checks

yet in the main canal. In all likelihood no water except that in the small ditch will be available for crops the present season. About 125,000 acres of Government land have been filed upon.

WATER SUPPLY.

The water supply in the Colorado River is abundant, at least sufficiently so to supply all present demands. The water is very muddy when taken from the river, containing a great deal of fine sediment of a reddish-brown color, which must make the keeping of the canal clean quite a problem, but it can no doubt be done. It is rich in plant food and will aid greatly in preserving the fertility of the soils to which it is applied. The soluble matter in the water, according to all analyses available at this time, amounts on the average to less than 100 parts per 100,000 of water. In the soluble matter lime, calculated as sulphate, makes up 40 per cent, the remainder being magnesium, potassium, and sodium chlorids and sulphates, with probably 20 per cent bicarbonates. Carbonates have not been found in more than very small quantities, and the presence of the gypsum would preclude all possibility of the accumulation of black alkali in a well-aerated soil. The use of such water is attended with no risk, provided the soils are not allowed to become water-logged. The amount of plant food in solution and in suspension makes the water valuable as a source of strength and nourishment to growing plants.

SOILS.

The soils of this portion of the delta are very uniform, all having been formed principally by the deposition of the finer sediment of the Colorado River. In some places sand has been mixed with this finer soil, making a sandy loam, or even in small areas a sand.

Five types were recognized and mapped, all of which are in places excessively alkaline, and even in places where the surface 6 feet shows no accumulation the soil is underlaid by an alkali-bearing clay subsoil. The following table shows the areas of each type of soil:

Areas of different soil types.

Soils.	Acres.	Per cent.
Dune sand	29,840	27.7
Imperial sand	1,020	1.0
Imperial sandy loam	23,710	21.9
Imperial loam	30,410	28.0
Imperial clay	23,120	21.4
Total	108,100	100.0

SOIL MAP

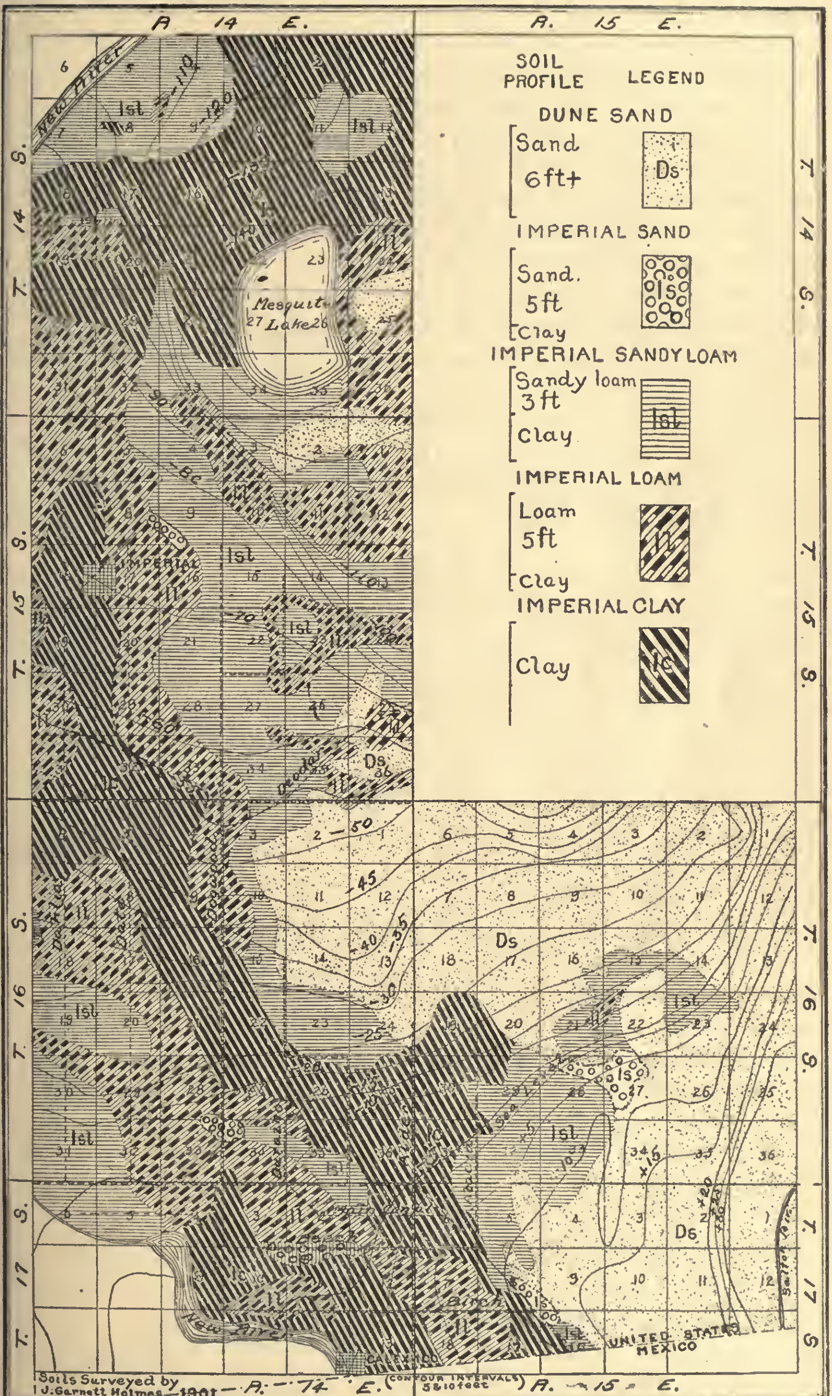

FIG. 1.—MAP SHOWING DISTRIBUTION OF SOIL TYPES IN THE IMPERIAL AREA, CALIFORNIA.

DUNE SAND.

The sand dunes of the area mapped are found along the eastern boundary, limiting the irrigable land along Salton River. The dunes are from 2 to 10 feet high, crescent shaped, and very rough and unlevel. They have been formed by the strong winds of the valley. The sand is of a reddish brown color, rather rotten, and often mixed with small particles of flocculated soil. When wet these particles break down, producing a sandy loam soil. These dunes are underlaid by the heavier soils of the delta.

Owing to the strong winds which have formed these dunes and which would blow the sands around if leveled, and the roughness of the country, requiring great expense for leveling it. it is doubtful if these sand dunes are of present agricultural value.

The sand dunes are usually free from alkali salts, 95 per cent of the soil carrying less than 0.2 per cent alkali, but directly south of Mesquite Lake there is an area of sand dunes the western part of which contains a high percentage of alkali.

IMPERIAL SAND.

The Imperial sand is found in only small areas and is composed of the same material as the sand dunes, the only difference being that the surface is level enough to permit of leveling for irrigation. It is usually found in the vicinity of the dunes. Only small isolated areas were mapped. The surface soil is sand, 5 feet deep, underlaid by loam or clay loam which contains alkali. This soil will undoubtedly prove to be the best in the valley for all of the garden crops or any crop requiring cultivation. It is adapted to cultivated crops and fruits which will withstand this climate.

This soil will very likely always be well drained and practically free from alkali salts, but if the subsurface water should rise to within 6 or 8 feet of the surface by reason of excessive irrigation great danger should be feared of the accumulation of alkali. The cultivation of the sand is safe at present, but the movements of water and alkali salts in it are rapid, and should a subsurface accumulation of water be permitted the alkali would speedily rise to the surface and injure the soil. Eighty-two per cent of the soil has less than 0.2 per cent alkali, and 18 per cent from 0.2 to 0.4 per cent alkali.

IMPERIAL SANDY LOAM.

This soil is found scattered pretty generally throughout the area mapped, there being in all 37 square miles, or 24,000 acres. As a rule the surface is covered with small dunes, which consists of the sandy loam soil blown by the wind and lodged beside bushes and other obstructions. In T. 16 S., R. 15 E.; T. 16 S., R. 14 E.; T. 15 S., R.

14 E. the surface is wind-scored and very unlevel, while along the bluff southwest of Mesquite Lake, in T. 15 S., R. 14 E., the land is much cut by gullies, in some places 8 or 10 feet deep.

The sandy loam soil is formed by the coarsest sediment of the Colorado River deposit mixed with wind-blown sand. The sandy loam extends to a depth of 3 feet and is underlaid by a loam or heavy loam. This soil will take water readily, and where level and free from alkali is adapted to cultivated crops or alfalfa. Some of the best and some of the worst lands of the valley are composed of this type. A reference to the alkali map will show that this soil ranges in alkali content from practically nothing to more than 3 per cent. Thirty-seven per cent of the soil has less than 0.2 per cent alkali, 21 per cent has from 0.2 to 0.4 per cent, and 42 per cent has more than 0.4 per cent alkali.

IMPERIAL LOAM.

The Imperial loam was found to comprise a part of each township mapped. The surface is smooth and level as a floor, almost devoid of vegetation. It has the peculiar, slick, shiny appearance often seen in localities where water has recently stood. It is the direct sediment of the Colorado River which has been deposited in strata when the area was under water. These strata are from 0.01 inch to 2 or 3 inches thick, resembling shale very much, in fact, to all external appearances being exactly similar. When water is applied, however, the soil softens up and is a reddish sticky loam, a little heavier than a silt loam. It is from 4 to 6 feet deep, underlaid by a clay or clay loam, and contains considerable organic matter, including an abundance of nitrogen and potash. When free from alkali it is well adapted to the growth of wheat, barley, and alfalfa. This soil is in the main alkaline and in some places to such a degree as to preclude all possibility of profitable agriculture. Of the 30,000 acres mapped 16½ per cent has less than 0.2 per cent alkali; 21½ per cent has from 0.2 to 0.4 per cent, while 62 per cent has more than 0.4 per cent alkali.

IMPERIAL CLAY.

The Imperial clay as soil or subsoil is found throughout the entire area. It is usually comparatively level, although in some places small hummocks have been blown up on its surface. It is this soil that surrounds both the towns of Calexico and Imperial—the only difference in the soils of the two districts being in the alkali content. The soil has been formed by the deposition of the finest sediment of the Colorado River and is stratified in the same way as the loam. It is a heavy, sticky, plastic soil, very much resembling the clay subsoil found in the Mississippi River Delta. When dry and in its natural state it exists in hard cakes and lumps, which may be cut with a knife

and is susceptible of taking a high polish. When wet the lumps are very plastic and sticky, making a refractory soil which it is very difficult to cultivate. Upon drying the soil becomes very hard and cracked. Sorghum and millet were grown this year on several hundred acres of this land in the vicinity of Calexico which produced good crops. The sorghum, however, was the best, the yield being 6 or 8 tons to the acre.

Cultivation of this clay soil will be very difficult. A similar soil is found in the Salt River Valley as a phase of the Glendale loess and is locally known as "slickens." The farmers of that neighborhood have considerable difficulty in managing this soil and it is not as refractory as much of the Imperial clay. Either annual crops or crops which can be cultivated throughout the growing season are productive of best results on this soil, for the heavy and hard crusts need to be broken up and thoroughly pulverized occasionally. Alfalfa does not do well on such a soil, for the crusts seem too hard and the soil too dense and impenetrable to permit the constant extension of the fine rootlets so essential to permanency in an alfalfa field. Deep plowing and thorough cultivation will in a few years greatly improve this soil.

Aside from the difficulties in the physical properties of the soil, the greater part of it contains too much alkali to warrant its continued cultivation. Two or three crops may be taken off the land, but the rise of the alkali is almost inevitable, and the cultivation of soils containing more than 0.4 per cent alkali is not recommended.

In the area surveyed there were 23,000 acres of this soil. Of this, 3 per cent carried less than 0.2 per cent alkali, 43 per cent carried from 0.2 to 0.4 per cent, and 54 per cent had more than 0.4 per cent alkali.

ALKALI IN THE SOIL.

By popular usage any harmful accumulation in the soil of salts of any kind is referred to as alkali, distinctions being made between districts containing a large amount of sodium carbonate and those which do not. The sodium carbonate areas are popularly called "black alkali" areas, and all others "white alkali" areas. The white alkali salts are usually found associated with the sodium carbonate in black alkali areas, while in the white alkali regions there is usually a predominance of the sulphates or chlorides, with smaller amounts of other salts. So far as is yet known, the amount of white alkali that crops will withstand is influenced more by the presence or absence of lime as a constituent of the soil than by the chemical composition of the salts. It has been determined by experiment, both in the field and in the laboratory, that where there is an excess of lime in the soil in the form of sulphate or carbonate, plants will withstand a greater percentage of alkali than where the lime content is small. In the Colorado Desert gypsum (sulphate of lime) and carbonate of lime are nearly always present in the soil.

ALKALI MAP

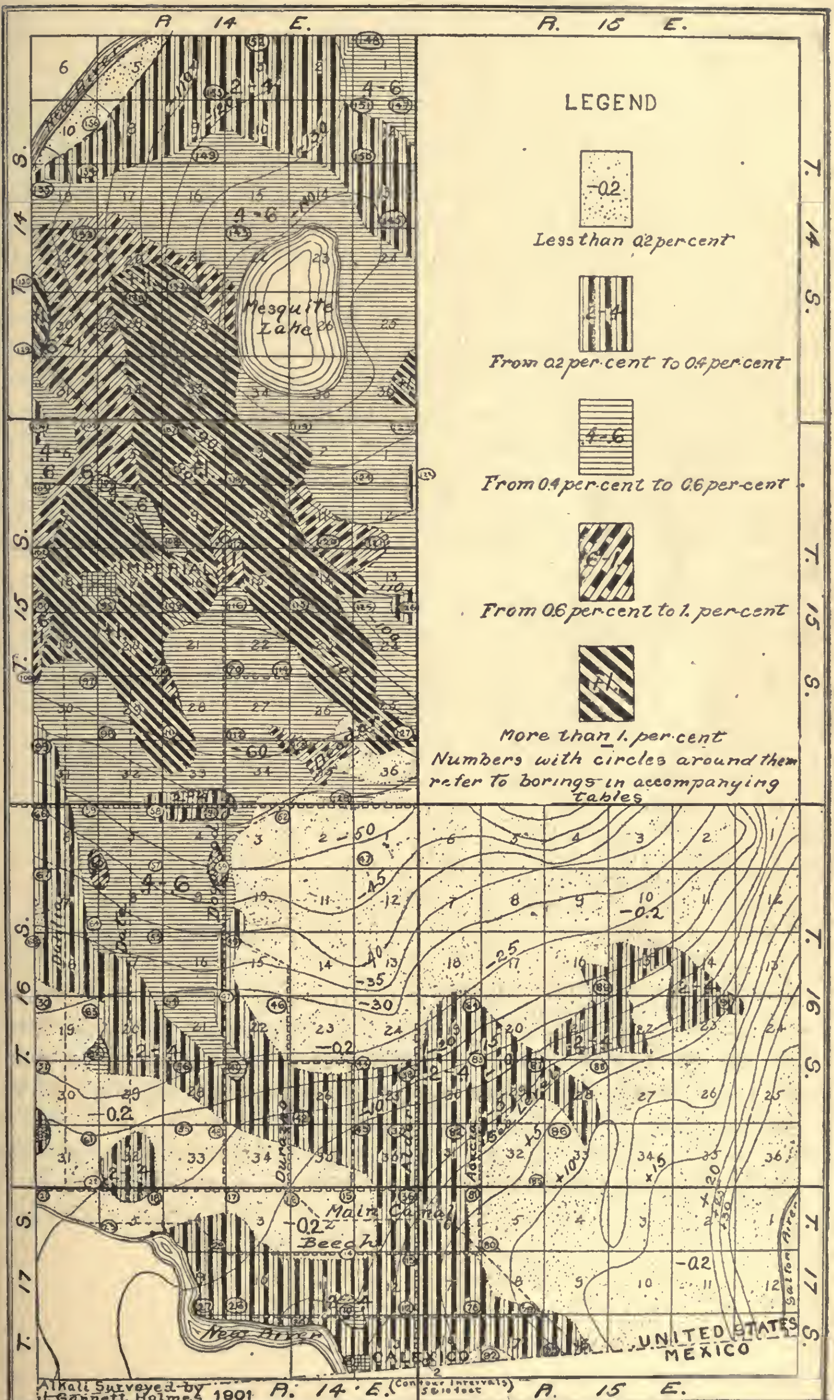

FIG. 2.—MAP SHOWING DISTRIBUTION OF ALKALI IN THE SOILS OF THE IMPERIAL AREA, CALIFORNIA.

CHEMICAL COMPOSITION OF THE ALKALI.

The alkali of this portion of the desert is all of the white kind, principally the chlorid of potassium and sodium. Lime is present both as sulphate and carbonate. No crops except sorghum and millet have as yet been grown, so the exact limitations for the different crops for this area were not established, although they certainly could not withstand a great deal more than the crops elsewhere. If the soils are kept well drained there is enough gypsum in the soil and water to preclude all possibility of there ever being an accumulation of the black alkali.

As the area is now below sea level, and the soils were most likely deposited in salt or brackish water when this was a part of the sea, and the alkali is principally common salt, the principal salt of the sea, we may directly conclude that the major part of the alkali came from the sea water, this alkali simply staying in the soil because the rainfall was insufficient to wash it out. The floods from the Colorado have brought in other salts, particularly sulphates, and much changed the chemical composition of the salts from their original composition as deposited from the sea.

The following table shows the results of the analysis of a mixture of eight samples of alkali crust collected from various places in the desert:

Analysis of mixture of eight samples of alkali crust from Imperial area, California, combined by a conventional method.

	Per cent.
$CaSO_4$ (calcium sulphate)	9.91
$MgSO_4$ (magnesium sulphate)	9.02
Na_2SO_4 (sodium sulphate)	.33
KCl (potassium chloride)	30.02
$NaHCO_3$ (sodium bicarbonate)	9.59
$NaNO_3$ (sodium nitrate)	8.91
NaCl (sodium chloride)	32.22
	100

The alkali exists either in the soil or subsoil throughout the area mapped. In many places where the soil is of open, porous nature this alkali has been washed out of the surface soil down into the subsoil, and in the case of the more sandy soils will very likely stay in the subsoil too deep to damage shallow-rooted crops, unless the soils are so filled up with water that the capillary power of the sandy soils can raise the standing water to the surface.

The alkali map accompanying this report (p. 11) outlines five grades of soil as to alkali content:

Grade of soil.	Acres.	Per cent of the area.
From 0 to 0.2 per cent	42,220	39.1
From 0.2 to 0.4 per cent	25,320	23.4
From 0.4 to 0.6 per cent	23,040	21.3
From 0.6 to 1 per cent	5,220	4.8
Over 1 per cent	12,300	11.4

These grades represent the average for the surface 6 feet, tests having been made for each foot in depth and the arithmetical mean taken. At the end of this report a table is given showing the per cent of alkali in each foot of depth for all the borings.

The 0 to 0.2 per cent grade is soil that is practically free from alkali. No crops but the most sensitive would be injured by this percentage. Almost all common crops will withstand from 0.2 per cent to 0.4 per cent. Barley, corn, alfalfa, watermelons, cantaloupes, and most of the berries, grapes, figs, apricots, and peaches will do almost as well in this grade of soil as in lands that contain much less, the chief danger in growing fruits being the fact that their roots are liable to go deep into the subsoil and thus reach the alkali accumulated there. Alfalfa will barely grow in the 0.4 to 0.6 per cent soil, even when well matured. If once a stand is secured it will struggle along, unless there be a concentration caused by the irrigation. Barley will produce a crop, though not first class. Pear trees will grow for a time at least, and if the subsoil be no worse than the surface and no concentration near the surface takes place they would thrive indefinitely.

All land that contains more that 0.6 per cent of alkali must be handled very carefully to produce any kind of crops except the most alkali resistant. Careful and proper methods of cultivation may result in washing enough of the alkali of the surface 2 or 3 feet into the subsoil so that shallow-rooted crops, such as annuals, can be grown. But until this surface reclamation takes place only such crops as sorghum, date palms, and sugar beets can be grown. On all the soils that contain more than 1 per cent of alkali date palms and saltbushes are the only crops that will thrive. In the Sahara date palms will grow on lands containing as much as 3 per cent of alkali.

The alkali map shows the conditions to a depth of 6 feet only, but as alkali salts have been known to rise to the surface from much greater depths, it is important to know the amount of alkali in the

deeper subsoils. For this purpose deep borings were taken at a number of places. The following table shows the results of these borings:

Results of deep borings.

[Per cent alkali in each foot of soil.]

Depth in feet.	Boring 12, SE. cor. sec. 12, T. 17 S., R. 14 E.		Boring 44, NW. cor. sec. 25, T. 16 S., R. 14 E.		Boring 92, SW. ¼ sec. 17, T. 17 S., R. 15 E.		Boring 95, NE. cor. sec. 19, T. 15 S., R. 14 E.	
		P. ct.		*P. ct.*		*P. ct.*		*P. ct.*
0 to 1	Loam	0.19	Sandy loam	−0.20	Loam	0.37	Clay loam	1.80
1 to 2	Loam	.27	Sandy loam	− .20	Loam	.24	Clay loam	1.88
2 to 3	Loam	.25	Sand	− .20	Clay loam	−.20	Clay loam	1.85
3 to 4	Clay	.21	Sand	− .20	Sand	−.20	Clay loam	1.88
4 to 5	Clay	.28	Sand	− .20	Sand	−.20	Clay loam	1.23
5 to 6	Clay loam	.25	Sand	− .20	Loam	−.20	Loam	1.22
6 to 7	Clay loam	.24	Sand	− .20	Clay loam	−.20	Loam	1.40
7 to 8	Clay	.34	Sand	− .20	Clay	−.20	Loam	1.30
8 to 9	Clay	.36	Sandy loam	.82	Clay	.30	Loam	1.35
9 to 10	Clay	.37	Clay	1.34	Clay	.40	Loam	1.30
10 to 11	Loam	.22	Sandy loam	.70	Clay	.54	Loam	1.10
11 to 12	Clay loam	.36	Sandy loam	.62	Clay	.62	Loam	1.00
12 to 13	Clay loam	.50			Clay	.56	Loam	1.20
13 to 14	Clay loam	.48			Clay	.73	Loam	1.10
14 to 15	Clay loam	.39			Loam	.84	Sandy loam	.84
15 to 16					Loam	.67	Sandy loam	.84
16 to 17							Sandy loam	.96
17 to 18							Sandy loam	.90

Inspection of this table shows that at every deep boring alkali was found in more or less harmful quantity in the subsoil. Even in boring 44, where the soil was light throughout the top 8 feet and free from harmful quantity of salt, as soon as the clay was reached, at 9 feet, a high percentage of alkali was found. The irrigation of such soil would be perfectly safe as long as the level of standing water did not rise sufficiently for the surface to be kept wet by capillarity. Should this happen the rise of the alkali, even though buried 8 feet, would be certain.

Aside from the alkali, which renders part of the soil practically worthless, some of the land is so rough from gullies or sand dunes that the expense of leveling it is greater than warranted by its value. In the 108,000 acres surveyed, 29,840, or 27.7 per cent, is sand dunes and rough land. Of the total area level enough to permit profitable cultivation, 17 per cent contains less than 0.2 per cent of alkali and 32 per cent contains from 0.2 per cent to 0.4 per cent. The remainder of the land, or 51 per cent, contains too much alkali to be safe except for resistant crops.

CONDITIONS OF AGRICULTURE AND POSSIBILITIES OF IMPROVEMENT.

Perhaps more than any other part of arid America this lower desert portion of the Colorado River delta must depend upon agriculture and agriculture alone for its support. The nearest mining territory in any direction is miles away. The climate is not such that tourists or pleasure seekers will help maintain the country, as is the case in many other parts of the Southwest. Every dollar gotten from the country

must come from the soil. To grow crops successfully in an arid country two things are absolutely necessary—the proper kind of soil and water. Experience long ago demonstrated that the greatest problem confronting the farmer in arid countries is the danger from harmful accumulations or the rising of alkali salts. Case after case is on record where either from the use of alkali-impregnated water or from the localizing of the small amount of alkali already in the soil large areas have been ruined, where when irrigation began there was no appreciable amount apparent in any of these soils. In nearly every irrigated region these alkaline areas seem to be a necessary adjunct. Much work has been done by the different experiment stations of the United States and this Bureau in the past few years in determining the amount of alkali various crops will withstand in these alkaline areas, and the following limitations have been established for the white alkali:

	Per cent.
Barley, sugar beets, sorghum	0.6 to 1.0
Alfalfa, wheat, corn	.2 to .4

Sorghum is an alkali-resisting plant and will very probably withstand more than sugar beets. By glancing at these figures and at the alkali map which accompanies this report it will be seen that for a great deal of the lands of the area mapped even the most alkali-resistant plants will not grow at the present time, before any accumulation at the surface has taken place from evaporation or concentration of seepage waters. The subsoil of all of the area is strongly impregnated with salts, a part of which must, in all except the very sandy soils, eventually reach the surface and greatly interfere with agriculture.

When looked at rationally it is easy to understand why this country is alkaline. It is part of an old desiccated sea bed and is all below the present sea level. The soils were deposited and saturated with sea water or brackish water, which evaporated and left them strongly impregnated with the salts in solution. The rainfall is so slight as never to penetrate the soils to any depth, so that very little salt has ever been washed out of them. Wells put down to subsurface water all over the valley find water which contains alkali—sometimes too much for domestic use. Salton salt works are at the bottom of the basin, where tons and tons of salt are taken from the surface of the ground each year, only to be replaced by the evaporation of seepage waters, which must, in part, be the drainage from this very country.

One hundred and twenty-five thousand acres of this land have already been taken up by prospective settlers, many of whom talk of planting crops which it will be absolutely impossible to grow. They must early find that it is useless to attempt their growth. On the bad alkali lands they should try to grow only crops suited to such lands. Test plots will be of very little value except for the year in which

they are made. The land may produce a crop for a year, or even two years, and then, having become thoroughly saturated, the alkali will rise and kill the crops. For the worst lands the best thing to do will be to immediately abandon them.

Much can be done to benefit, at least temporarily, the alkali conditions of the delta by careful and intelligent methods of cultivation and irrigation. On the heavier soils as quickly as possible enough organic matter should be plowed under to ameliorate in a degree the impervious clay properties and allow a more rapid percolation of the water. Water should in all cases be applied to the surface. Only on the most sandy soils should furrow irrigation be practiced at all, for soon the furrows would be as white as the ditch banks already are throughout the district. The alkali is transported by the water; so if the water can be applied to the surface and be kept going down all the time, and the subsoil offers good drainage, then alkali lands can be reclaimed simply by copious surface flooding; but if, on the other hand, the soil be heavy and compact, not conducive to rapid percolation, then the tendency will be to fill up the soil with water— the alkali going down for a while and then again coming to the surface at the rise of the water table. This action is especially harmful if the subsoil contains a greater percentage of alkali than the surface.

So the permanent reclamation of alkali lands depends wholly upon the drainage, natural or artificial. If the natural drainage is not good, then artificial drains must be introduced. For the heavier soils of the delta artificial drains would have to be so close together that the expense would be too great to be practicable, at least for the present, so the natural drainage alone will have to be depended upon. Standing water at Colexico is less than 50 feet below the surface, while at Imperial it is less than 30, and at this point moisture comes to within 5 feet of the surface. Nearly all this subsurface water is salty, so if the water from the surface reaches this and raises it before it drains several miles laterally, then the conditions will be aggravated rather than bettered. If the whole country is irrigated at the same time sufficiently to wash the alkali down below the reach of plant roots, then the subsoil of the whole country will be filled and lateral drainage be very slow, so the reclamation of the lands already badly alkaline seems almost a hopeless task.

No doubt the best thing to do is to raise crops like the sugar beet, sorghum, and date palm (if the climate will permit), that are suited to such alkaline conditions, and abandon as worthless that which contains too much alkali to grow those crops. There is not rain enough to grow salt bushes without irrigation, but with irrigation they would do well, and serve as profitable food for cattle, sheep, or goats.

SUMMARY.

Farming in the desert to ordinary crops, fruit or alfalfa will be impossible on much of the land, and risky on all unless special precautions are taken to prevent the rise of the alkali. Of the level lands only 17 per cent have less than 0.2 per cent alkali, while 32 per cent have from 0.2 to 0.4 per cent. This 49 per cent of the area can be farmed to nearly all crops as long as the accumulation of the alkali at the surface is prevented. The remainder of the land, or 51 per cent, will have to be farmed to alkali-resistant crops. Date palms, sorghum, sugar beets, and barley will likely be most successful. Even where farmed to these resistant crops the greatest precaution should be taken to prevent an accumulation of alkali at or near the surface.

The claims for the fertility of this country are based upon the experience gained from irrigation along the Colorado River below Yuma. An examination of the country reveals the fact that the conditions below Yuma are very different from those in the Imperial area, and the agriculture of the two areas is not comparable. The soils of the bottom lands below Yuma are lighter in texture, more pervious to water, contain less alkali, and are, many of them, well adapted to alfalfa.

SALT CONTENT OF THE SOIL.

Boring No.	Location.	Type of soil.	First foot.	Second foot.	Third foot.	Fourth foot.	Fifth foot.	Sixth foot.	Grade of land.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
2	SE. cor. sec. 18, T. 17 S., R. 15 E	Imperial clay	−0.20	−0.20	0.20	0.28	0.48	0.46	0.2 − 0.4
6	Cen. E. ½ sec. 7, T. 17 S., R. 15 E	do	.25	.24	.22	.22	−.20		.2 − .4
8	SW. cor. sec. 13, Calexico	do	.40	.87	.52	.25	.21	−.20	.2 − .4
10	NE. cor. sec. 14. T. 17 S., R. 14 E	do	.24	.44	.90	.46	.38	−.20	.4 − .6
12	SE. sec. 12, T. 17 S., R. 14 E	do	−.20	.27	.25	.21	.28	.25	.2 − .4
13	NE. cor. sec. 12, T. 17 S., R. 14 E	do	.25	.27	.26	.25	.26	.28	.2 − .4
14	NE. cor. sec. 11, T. 17 S., R. 14 E	Imperial sand	−.20	−.20	−.20	−.20	−.20	−.20	0 − .2
15	NE. cor. sec. 2, T. 17 S., R. 14 E	Imperial sandy loam	−.20	−.20	−.20	−.20	.22	.30	0 − .2
16	NE. cor. sec. 3, T. 17 S., R. 14 E	Imperial loam	−.20	−.20	.22	−.20	−.20		0 − .2
17	NE. cor. sec. 4, T. 17 S., R. 14 E	Imperial clay	−.20	.22	.28	−.20	−.20	−.20	0 − .2
18	NE. cor. sec. 5, T. 17 S., R. 14 E	Imperial loam	−.20	−.20	−.20	−.20	−.20	−.20	0 − .2
19	S. cen. sec. 32, T. 16 S., R. 14 E	do	.64	−.20	.24	.32	.33	.33	.2 − .4
21	SW. cor. sec. 31, T. 16 S., R. 14 E	Imperial sandy loam	−.20	.24	−.20	−.20	−.20	−.20	0 − .2
22	SW. cor. sec. 32, T. 16 S., R. 14 E	do	−.20	−.20	−.20	−.20	.21		0 − .2
23	W. cen. SW. ¼ sec. 5, T. 17 S., R. 14 E	do	−.20	−.20	−.20	−.20	−.20	−.20	0 − .2
25	NW. cor. sec. 14, T. 17 S., R. 14 E	Imperial loam	−.20	.25	.32	.23	.29	.40	.2 − .4
26	SW. cor. sec. 10, T. 17 S., R. 14 E	do	.29	28	.52	.31	.21	−.20	.2 − .4
27	S. cen. sec. 9, T. 17 S., R. 14 E	Imperial clay	−.20	−.20	−.20	−.20	.22	−.20	0 − .2
28	SE. cor. sec. 4, T. 17 S., R. 14 E	do	.29	.32	.56	.47	.23	.22	.2 − .4
30	NW. cor. sec. 19, T. 16 S., R. 14 E	Imperial sandy loam	.63	.23	.22	−.20	.29	.34	.2 − .4
31	NW. cor. sec. 30, T. 16 S., R. 14 E	do	−.20	.21	−.20	−.20	−.20	.21	0 − .2
36	NE. cor. sec. 1, T. 17 S., R. 14 E	Imperial clay	.41	.28	−.20	−.20	−.20	−.20	.2 − .4
37	NE. cor. sec. 36, T. 16 S., R. 14 E	do	.44	.32	.20	.23	−.20	−.20	.2 − .4
38	NE. cor. sec. 25, T. 16 S., R. 14 E	do	.56	.23	−.20	−.20	−.20	−.20	.2 − .4
41	NW. cor. sec. 27, T. 16 S., R. 14 E	do	.21	.67	.58	.72	.70	.66	.4 − .6
42	SW. cor. sec. 26, T. 16 S., R. 14 E	Imperial loam	.32	.26	.35	.31	.43	.46	.2 − .4
43	NW. cor. sec. 36, T. 16 S., R. 14 E	Imperial clay	.50	.58	.31	.28	.24	.23	.2 − .4
44	NW. cor. sec. 25, T. 16 S., R. 14 E	Imperial sandy loam	−.20	−.20	−.20	−.20	−.20	−.20	0 − .2
46	NE. cor. sec. 22, T. 16 S., R. 14 E	do	.21	.32	−.20	−.20	−.20	−.20	0 − .2
47	NW. cor. sec. 22, T. 16 S., R. 14 E	Imperial clay	.51	.48	.29	.27	−.20	−.20	0 − .2
48	NW. cor. sec. 34, T. 16 S., R. 14 E	Imperial sand	−.20	−.20	−.20	−.20	−.20	−.20	0 − .2
49	NE. cor. sec. 16, T. 16 S., R. 14 E	Imperial loam	.38	.45	−.20	−.20	.30	.43	.2 − .4
50	NE. cor. sec. 9, T. 16 S., R. 14 E	do	1.60	1.10	1.00	.77	.59	.50	.6 − 1
51	NE. cor. sec. 4, T. 16 S., R. 14 E	do	.36	.60	.41	.26	.25	.20	.2 − .4
52	NE. cor. sec. 3, T. 16 S., R. 14 E	Imperal sandy loam	.21	−.20	−.20	−.20	−.20	.28	0 − .2
53	NE. cor. sec. 17, T. 16 S., R. 14 E	Imperial clay	.56	.60	.44	.34	.28	.29	.4 − .6
54	NE. cor. sec. 20, T. 16 S., R. 14 E	Imperial loam	.52	.51	.40	.38	.42	.46	.4 − .6
55	NE. cor. sec. 32, T. 16 S., R. 14 E	do	−.20	−.20	−.20	−.20	−.20	−.20	0 − .2
56	NE. cor. sec. 29, T. 16 S., R. 14 E	do	−.20	−.20	.30	.41	.41	.59	.2 − .4
57	NE. cor. sec. 8, T. 16 S., R. 14 E	Imperial clay	−.20	.33	.40	.38	.34	.22	.2 − .4
58	NE. cor. sec. 5, T. 16 S., R. 14 E	do	−.20	.32	.33	.26	.33	.25	.2 − .4
59	NE. cor. sec. 6, T. 16 S., R. 14 E	do	.30	.61	.50	.41	.42	.40	.4 − .6

60	NE. cor. sec. 7, T. 16 S., R. 14 E	Imperial loam	.57	.74	.79	.79	.73	.66	.6 – 1
61	NE. cor. sec. 31, T. 16 S., R. 14 E	Imperial sandy loam	.26	—.20	—.20	—.20	—.20	—.20	0 – .2
62	NE. cor. sec. 30, T. 16 S., R. 14 E	Imperial loam	—.20	.21	.43	.85	1.22	.52	.4 – .6
63	S. E. cor. sec. 19, T. 16 S., R. 14 E	Imperial sandy loam	—.20	.21	.24	.20	—.20	—.20	0 – .2
64	NE. cor. sec. 18, T. 16 S., R. 14 E	Imperial loam	—.20	.33	.50	.48	.50	.62	.4 – .6
65	NW. cor. sec. 31, T. 16 S., R. 14 E	Imperial sandy loam	.61	.37	—.20	—.20	—.20	—.20	.2 – .4
66	NW. cor. sec. 6, T. 16 S., R. 14 E	Imperial clay	—.20	.32	.29	.24	—.20	.23	.2 – .4
67	NW. cor. sec. 7, T. 16 S., R. 14 E	do	.38	.44	.24	.21	—.20	—.20	.2 – .4
69	NW. cor. sec. 18, T. 16 S., R. 14 E	Imperial sandy loam	—.20	—.20	—.20	—.20	—.20	—.20	0 – .2
70	SW. cor. sec. 22, T. 15 S., R. 14 E	do	—.20	.53	.60	.76	1.00	.78	.4 – .6
72	6 miles NW. of Imperial	Imperial loam	1.60	1.60	.62	.31	.22	.28	.6 – 1
78	SE. cor. sec. 7, T. 17 S., R. 15 E	do	.86	.12	.24	.30	.38	.50	.2 – .4
79	SE. cor. sec. 8, T. 17 S., R. 15 E	Imperial clay	.38	.38	.22	.24	—.20	—.20	.2 – .4
80	NE. cor. sec. 7, T. 17 S., R. 15 E	Imperial loam	.28	.36	.22	—.20	—.20	—.20	0 – .2
81	NE. cor. sec. 6, T. 17 S., R. 15 E	Imperial sandy loam	—.20	—.20	—.20	—.20	—.20	—.20	0 – .2
82	NE. cor. sec. 31, T. 16 S., R. 15 E	Imperial clay	.34	.33	.29	.33	.29	.28	.2 – .4
83	NE. cor. sec. 30, T. 16 S., R. 15 E	do	.44	.38	—.20	—.20	—.20	.23	.2 – .4
84	NE. cor. sec. 19, T. 16 S., R. 15 E	do	.58	.56	.51	.25	.18	.24	.2 – .4
85	NE. cor. sec. 5, T. 17 S., R. 15 E	Imperial sandy loam	—.20	.22	.30	.20	—.20	—.20	0 – .2
86	NE. cor. sec. 32, T. 16 S., R. 15 E	do	—.20	—.20	—.20	—.20	—.20	—.20	0 – .2
87	NE. cor. sec. 29, T. 16 S., R. 15 E	do	—.20	.27	.43	.20	.23	.33	.2 – .4
88	NE. cor. sec. 28, T. 16 S., R. 15 E	Imperial sand	—.20	—.20	—.20	—.20	—.20	.33	0 – .2
89	NE. cor. sec. 21, T. 16 S., R. 15 E	Imperial sandy loam	.24	.50	.20	.24	.28	.22	.2 – .4
91	NE. cor. sec. 23, T. 16 S., R. 15 E	do	.33	—.20	.24	.22	—.20	.22	.2 – .4
92	Cen. SW. ¼ sec. 17, T. 17 S., R. 15 E	Imperial loam	.37	.24	—.20	—.20	—.20	—.20	0 – .2
93	SW. cor. sec. 16, T. 17 S., R. 15 E	Imperial clay	.21	.27	.28	.28	.18	.18	.2 – .4
95	NE. cor. sec. 19, T. 15 S., R. 14 E	do	1.80	1.88	1.85	1.88	1.23	1.22	1+
97	NE. cor. sec. 30, T. 15 S., R. 14 E	do	.73	.94	.61	.47	.45	.47	.4 – .6
98	NE. cor. sec. 31, T. 15 S., R. 14 E	do	.44	.48	.29	.30	.33	.32	.4 – .6
99	NW. cor. sec. 31, T. 15 S., R. 14 E	Imperial loam	.49	.31	—.20	—.20	.25	—.20	.2 – .4
100	NW. cor. sec. 30, T. 15 S., R. 14 E	do	.43	.40	.69	.82	.68	.80	.6 – 1
101	NW. cor. sec. 19, T. 15 S., R. 14 E	do	.59	.50	.45	.72	1.04	.87	.6 – 1
102	NW. cor. sec. 18, T. 15 S., R. 14 E	do	.71	1.02	.68	.62	.64	.64	.6 – 1
103	NW. cor. sec. 7, T. 15 S., R. 14 E	do	.79	.84	.25	.48	.42	.38	.4 – .6
104	NE. cor. sec. 7, T. 15 S., R. 14 E	do	.22	.69	.58	.32	.38	.60	.4 – .6
105	NE. cor. sec. 6, T. 15 S., R. 14 E	Imperial loam	.73	.66	.46	.83	1.00	1.02	.6 – 1
106	NW. cor. sec. 6, T. 15 S., R. 14 E	do	.37	.55	.28	— .20	—.20	—.20	.2 – .4
107	NE. cor. sec. 5, T. 15 S., R. 14 E	Imperial sandy clay	+3.00	3.00	+3.00	+3.00	3.00	3.00	1+
108	SE. ¼ sec. 8, T. 15 S., R. 14 E	Imperial loam	— .20	— .20	.51	.89	.81	.53	.4 – .6
109	NE. cor. sec. 20, T. 15 S., R. 14 E	do	+3.00	+3.00	+3.00	3.00	3.00	1.86	1+
110	NE. cor. sec. 29, T. 15 S., R. 14 E	Imperial sandy loam	.24	.73	.72	.56	.76	.63	.6 – 1
111	NE. cor. sec. 32, T. 15 S., R. 14 E	Imperial loam	.69	1.22	1.02	1.25	1.25	1.20	1+
112	NE. cor. sec. 33, T. 15 S., R. 14 E	Imperial sandy loam	—.20	—.20	.22	.44	1.07	.79	.4 – .6
113	NE. cor. sec. 34, T. 15 S., R. 14 E	Imperial loam	1.06	1.61	.63	.28	.64		.6 – 1
114	NE. cor. sec. 27, T. 15 S., R. 14 E	do	.76	.89	.66	.41	.26	.31	.4 – .6
115	NE. cor. sec. 22, T. 15 S., R. 14 E	Imperial sandy loam	.66	1.85	1.21	1.25	1.41	1.62	1+
116	NE. cor. sec. 21, T. 15 S., R. 14 E	do	— .20	— .20	.85	.72	.56	.26	.4 – .6
117	NE. cor. sec. 16, T. 15 S., R. 14 E	do	1.04	1.07	.72	.51	.29	.45	.6 – 1
118	NE. cor. sec. 9, T. 15 S., R. 14 E	Imperial loam	+3.00	+3.00	2.01		1.03	1.45	1+
119	NE. cor. sec. 3, T. 15 S., R. 14 E	Imperial sandy loam	— .20	— .20	.47	.73	1.38	.98	.6 – 1
120	S. cen. sec. 11, T. 15 S., R. 14 E	Imperial loam	1.10	.74	.44	.54	.75	1.10	.6 – 1
121	S. cen. sec. 12, T. 15 S., R. 14 E	do	1.02	1.22	.50	.41	.37	.44	.6 – 1

Salt content of the soil—Continued.

Boring No.	Location.	Type of soil.	First foot.	Second foot.	Third foot.	Fourth foot.	Fifth foot.	Sixth foot.	Grade of land.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
122	NE. cor. sec. 12, T. 15 S., R. 14 E	Imperial loam	.66	.49	.25	−0.20	−0.20	−0.20	.2 − .4
123	NE. cor. sec. 1, T. 15 S., R. 14 E	do	.48	.86	.54	.36	.40	.52	.4 − .6
124	N. E. cor. sec. 11, T. 15 S., R. 14 E	do	.44	.38	.47	.35	.27	.37	.4 − .6
125	N. E. cor. sec. 23, T. 15 S., R. 14 E	do	.80	.62	.32	.28	.28	.36	.4 − .6
126	N. E. cor. sec. 24, T. 15 S., R. 14 E	do	−.20	−.20	.46	.41	.31	.35	.2 − .4
127	N. E. cor. sec. 36, T. 15 S., R. 14 E	do	+3.00	+3.00	1.92	1.01	.90	.91	1+
128	S. E. cor. sec. 35, T. 15 S., R. 14 E	Imperial sand	.29	.40	.40	.26	.25	1.00	.4 − .6
129	S. W. cor. sec. 30, T. 14 S., R. 14 E	Imperial loam	3.00	2.02	1.19	.55	.42	.24	1+
130	S. W. cor. sec. 19, T. 14 S., R. 14 E	Imperial clay	3.00	2.14	.71	.62	.48	.41	1+
132	E. cen. sec. 30, T. 14 S., R. 14 E	do	1.30	1.74	1.00	.59	.55	.50	.6 − 1
133	NE. cor. sec. 19, T. 14 S., R. 14 E	Imperial loam	1.02	.90	.66	.61	.58	.58	.6 − 1
134	NE. cor. sec. 18, T. 14 S., R. 14 E	Imperial clay	.39	.45	.25	.20	−.20	−.20	.2 − .4
135	W. cen., sec. 18, T. 14 S., R. 14 E	Imperial loam	.83	.68	.41	.43	.37	.33	.4 − .6
138	N. cen., sec. 29, T. 14 S., R. 14 E	Imperial clay	1.06	3.00	2.04	1.60	1.24	1.24	1+
142	NE. cor. sec. 29, T. 14 S., R. 14 E	do	+3.00		+3.00		+3.00		1+
143	NE. cor. sec. 21, T. 14 S., R. 14 E	do	.77	.65	.51	.30	.25	−.20	.4 − .6
145	N. cen. sec. 4, T. 14 S., R. 14 E	Imperial sandy loam	−.20	.22	.22	.27	.45	.56	.2 − .4
147	NE. cor. sec. 12, T. 14 S., R. 14 E	Imperial clay	.70	.46	.39	.39	.39	.38	.4 − .6
148	NW. cor. sec. 1, T. 14 S., R. 14 E	do	.57	.56	.42	.33	.32	.31	.4 − .6
149	N. cen. sec. 16, T. 14 S., R. 14 E	do	.33	.56	.57	.46	.42	.38	.4 − .6
150	NE. cor. sec. 14, T. 14 S., R. 14 E	Imperial sandy loam	.64	.76	.43	.25	.23	−.20	.2 − .4
151	NE. cor. sec. 11, T. 14 S., R. 14 E	do	.71	1.00	.59	.46	.34	.29	.4 − .6
152	N. cen. sec. 3, T. 14 S., R. 14 E	Imperial clay	.43	.43	.29	.22	.14		.2 − .4
153	NE. cor. sec 9, T. 14 S., R. 14 E	Imperial sandy loam	.20	.42	.35	.27	.22	.21	.2 − .4
156	E. cen. sec. 7, T. 14 S, R. 14 E	do	−.20	.23	.20	−.20	−.20	−.20	0 − .2

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